LEEDS PHILOSOPHICAL AND LITERARY SOCIETY.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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SIR R. S. BALL, PRESIDENT, in the Chair.

Edward John Griffin, Commander R.N.R., Commander R.M.S. *Moor*, Union Steamship Co., Southampton;
J. Nevil Maskelyne, 88 Trinity Road, Upper Tooting, S.W.;
Ambrose Swasey, Cleveland, Ohio, U.S.A.;
John Vaughan, Sub-Lieut. R.N.R., Commander China Navigation Co., Shanghai, and 42 Aubert Park, Highbury, N.; and
Thomas Emley Young, B.A., President of the Institute of Actuaries, 108 Evering Road, Stoke Newington, N.,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Eric Doolittle, B.Sc., Assistant, Flower Observatory, University of Pennsylvania, Philadelphia, Pa., U.S.A. (proposed by T. J. J. See);
Rev. Kingsbury Jameson, M.A., Highfield, Hendon (proposed by Alfred H. Fison);
Alfred Taylor, Messrs. T. Cooke & Sons, Buckingham Works, York (proposed by Robert Wigglesworth).

Eighty-five presents were announced as having been received since the last meeting, including, amongst others :—

The collected works of Arthur Cayley, vol. xiii., presented by the Cambridge University Press ; Annals of the Royal Observatory, Cape of Good Hope, vol. iii. (The Cape Photographic Durchmusterung, Part 1) ; vols. vi., vii. (Determination of the Solar Parallax and the Mass of the Moon from Heliometer Observations of *Iris*, *Victoria*, and *Sappho*) ; Results of Meridian Observations made during 1861–65 under the direction of Sir Thomas Maclear, reduced and printed under the direction of David Gill ; Appendix to Cape Meridian Observations 1890–91 (Star Correction Tables by W. H. Finlay), presented by the Observatory.

On the Parallax of Sirius and of α Gruis. By David Gill, C.B., F.R.S., &c., Her Majesty's Astronomer at the Cape.

In connection with the preparation for press of a work containing determinations of the parallaxes of the 1st magnitude stars of the Southern Hemisphere, I have recently discussed a series of observations for the parallax of *Sirius* made by me with the Cape Heliometer in the years 1888 and 1889.

The results seem to be of sufficient interest for communication in a brief form to the Society. The details will appear subsequently in the *Annals* of the Cape Observatory.

The selected comparison stars were :—

γ = B.D. − 16° 1593 ; mag. 8·7 ; P. angle from *Sirius*			279°·17 ;	S = 4310″
δ = B.D. − 16° 1623 ; „ 8·7 ; „ „ „			101·26 ;	S = 4536
	Difference	...	177°·91	226″
	Sum	...		8846″

The parallax factors for the difference and sum of the distances are :—

For $\delta - \gamma$ 1·997 R cos ($\odot$ − 15°·6)

$\delta + \gamma$ 0·023 R cos ($\odot$ − 105°·5)

so that the mean position angle is nearly in the major axis of the parallactic ellipse. The pair is thus a very favourable one for our purpose, except that the comparison stars are rather too faint for the most exact measurement.

The observations were arranged symmetrically—*i.e.* in the order γ, δ, δ, γ, or δ, γ, γ, δ—so that the mean instant of observation for each distance is nearly the same.

The light of *Sirius* was diminished by suitable wire gauze screens till the reduced image was similar in every respect to the images of the comparison stars when the latter were viewed through the non-obscured segment of the object glass. The

reversing prism was used symmetrically throughout, so as entirely to eliminate any subjective error depending on the direction of measurement with respect to the vertical.

The heliometer scale readings, converted into arc with an adopted mean scale-value, were corrected for errors of the screw and scale divisions, for refraction, aberration, and proper motion to 1889·0.

The sum and difference of the two mean measured distances γ and δ were then taken for each night of observation, and the differences were then corrected for variation of scale-value on the assumption that the sum of the distances should be a constant, the correction being

$$0{\cdot}025 \quad \{8846''{\cdot}62-(\gamma+\delta)\}.$$

In only three instances did this scale-value correction amount to 0″·01.

Putting $(\delta'-\gamma')$ for the values of $(\delta-\gamma)$ thus corrected, and assuming the true mean value of

$$\delta'-\gamma' = 226''{\cdot}100+x,$$

and adopting for the proper motion of the centre of gravity of the system of *Sirius*

$$\mu_\alpha = -0^s{\cdot}0374\ (t-1889{\cdot}0)$$
$$\mu_\delta = -1''{\cdot}2064\ (t-1889{\cdot}0)$$

and taking the orbital motion of the bright component of the system from Auwers' table, *Ast. Nach.* 3085, the following equations of condition were derived :—

		Weight.	O−C.
1888 Mar. 30	$x-0{\cdot}76y+1{\cdot}97\pi = +0''{\cdot}506-1{\cdot}52\Delta\beta$	1	−0″·018
Apr. 2	$x-{\cdot}75+1{\cdot}99 = +{\cdot}523-1{\cdot}76$	1	−·009
23	$x-{\cdot}69+1{\cdot}91 = +{\cdot}598-2{\cdot}06$	1	+·092
26	$x-{\cdot}68+1{\cdot}88 = +{\cdot}500-1{\cdot}56$	1	+·004
27	$x-{\cdot}68+1{\cdot}87 = +{\cdot}431-1{\cdot}94$	1	−·061
Sept. 28	$x-{\cdot}26-1{\cdot}97 = -{\cdot}821+1{\cdot}20$	1	+·096
29	$x-{\cdot}26-1{\cdot}97 = -{\cdot}817+1{\cdot}10$	½	+·090
Oct. 1	$x-{\cdot}25-1{\cdot}98 = -{\cdot}916+1{\cdot}42$	1	−·006
2	$x-{\cdot}25-1{\cdot}99 = -1{\cdot}019+1{\cdot}27$	1	−·106
4	$x-{\cdot}24-1{\cdot}99 = -{\cdot}905+1{\cdot}37$	1	+·008
7	$x-{\cdot}23-1{\cdot}99 = -{\cdot}950+1{\cdot}13$	1	−·038
1889 Mar. 24	$x+{\cdot}22+1{\cdot}95 = +{\cdot}537-2{\cdot}38$	½	−·033
Apr. 21	$x+{\cdot}30+1{\cdot}93 = +{\cdot}364-2{\cdot}40$	1	−·202
22	$x+{\cdot}30+1{\cdot}92 = +{\cdot}849-1{\cdot}59$	½	+·287
23	$x+{\cdot}31+1{\cdot}91 = +{\cdot}465-1{\cdot}50$	½	−·095
25	$x+{\cdot}31+1{\cdot}89 = +{\cdot}674-1{\cdot}63$	1	+·122

On 1888 September 29 and 1889 March 24, April 22 and 23 the images were very diffused (I 3, S 3 and 3–4), and the corresponding equations have received half weight.

In these equations

y is the correction applicable to the adopted correction for the annual change of $(\delta' - \gamma')$.

π is the parallax of *Sirius*.

$\Delta\beta$ is the correction to the constant of refraction of the principal star as compared with that of the comparison star. That is to say, if the refraction of the comparison stars in zenith distance is

$$\beta \tan \zeta,$$

that of the principal star is assumed to be

$$(\beta + \Delta\beta) \tan \zeta,$$

and the factor of $\Delta\beta$ is $\tan \zeta \cos (p - q)$.

Since the observations were not so arranged as to permit the determination of $\Delta\beta$, we find the values of x, y, and π in terms of $\Delta\beta$.

Having regard to the weights, the normal equations are :—

$$\begin{array}{llll} +14{\cdot}00x - 3{\cdot}90y + 5{\cdot}43\pi = -0''{\cdot}498 - 9{\cdot}38\Delta\beta \\ -3{\cdot}90 \quad +3{\cdot}18 \quad -2{\cdot}20 \quad -0{\cdot}007 + 3{\cdot}13 \\ +5{\cdot}43 \quad -2{\cdot}20 \quad +53{\cdot}01 \quad +18{\cdot}640 - 45{\cdot}15 \end{array}$$

Solving these, and substituting the resulting values of x, y, and π in the original equations we get the following results :—

$$\begin{array}{llll} x = -0''{\cdot}164 - 0{\cdot}36\Delta\beta\,; & \text{weight } 7{\cdot}4\,; & \text{probable error } \pm 0''{\cdot}0257 \\ y = +0{\cdot}053 - 0{\cdot}02\Delta\beta\,; & \text{,,} \quad 2{\cdot}1\,; & \text{,,} \quad \text{,,} \quad \pm 0{\cdot}0485 \\ \pi = +0{\cdot}370 - 0{\cdot}82\Delta\beta\,; & \text{,,} \quad 50{\cdot}7\,; & \text{,,} \quad \text{,,} \quad \pm 0{\cdot}0097 \end{array}$$

$$[pvv] = 0{\cdot}1405 \qquad \frac{[pvv]}{n-3} = 0{\cdot}0108$$

and the probable error of an observation of weight unity $\pm 0''{\cdot}070$. The residuals are given in the right-hand column beside the equations.

It is very improbable that the value of $\Delta\beta$ is a sensible quantity. In the years 1881–83 I made a series of seventy-nine observations with my 4-inch heliometer (*Mem. R.A.S.* vol. xlviii. pp. 83–97) to determine the parallax of *Sirius* relative to the stars, Lal. 12936, mag. $7\frac{3}{4}$, and Lal. 13129, mag. 8, and found for the value of the parallax

$$\pi = +0''{\cdot}370\,;\ \text{probable error } \pm 0''{\cdot}009.$$

In this series the systematic difference between E. and W. observations was only $0''\cdot007$, and the effect of regarding x_W as different from x_E was to change the resulting value of the parallax by only $0''\cdot001$ from that found by the assumption that none of the observations were affected by systematic error. The exact agreement of the present result with that of my previous determination—notwithstanding a difference of about 40° in position angle of the comparison stars—points also to non-existence of systematic error depending on $\Delta\beta$.

We have now from reliable heliometer observations the following results for the parallax of *Sirius* :—

		Prob. Error.	Mean.	Prob. Error.
Gill	Cape 1881–83	$+0''\cdot370 \pm 0''\cdot009$ *	$+0''\cdot370$	$\pm 0''\cdot007$
	Cape 1888–89	$+0\cdot370 \pm 0\cdot0097$ †		
Elkin...Cape	1881–82	$+0''\cdot407 \pm 0''\cdot018$ ‡	$+0''\cdot407$	$\pm 0''\cdot018$
		Mean	$+0''\cdot374$	$\pm 0''\cdot006$

We may therefore regard the parallax of *Sirius* relative to average comparison stars of about $8\frac{1}{2}$ magnitude as now satisfactorily determined, and the corrections depending on a parallax of $0''\cdot37$ may with advantage be introduced in the apparent places of *Sirius* given in the national ephemerides.

Parallax of α Gruis.

It is stated above that the comparison stars employed for *Sirius* are rather too faint for the most exact measurement. In the case of *α Gruis* I found a very symmetrical pair of comparison stars of 8th magnitude, and as the observations yield the smallest residuals which I have yet met with, the results of the observations may be of interest as illustrating the accuracy attainable with a good heliometer under the most favourable conditions.

The comparison stars were

γ = G. xxi . 1712	mag. 8 .	P. angle from *α Gruis*		$259°\cdot6$;	distance	$3670''$
δ = G. xxii . 187	„ 8 .	„	„	$77°\cdot8$;	„	3510
		Difference		$181°\cdot8$		$160''$

with the parallax factors

For $\gamma - \delta$ $\quad 1\cdot963 \text{ R cos } (\odot - 51°\cdot5)$

$\gamma + \delta$ $\quad 0\cdot018 \text{ R cos } (\odot - 22°\cdot6)$

* *Mem. R.A.S.* vol. xlviii. pp. 83–97. † Present paper.

‡ *Mem. R.A.S.* vol. xlviii. pp. 97–116.

The observations were made with the same precautions as in the case of *Sirius*. Kobold's value of the proper motion of *α Gruis* (*Ast. Nach.* 3435), based on Auwers' researches, was adopted, viz.—

$0''.205$ in the direction p $148°.8$.

Projecting the correction for this motion on the observed distances, and forming equations of condition in the same manner as those for *Sirius*, we get :—

1888		Weight.	O−C.
Apr. 27	$x-0.68y+1.92\pi=+0''.037-1.71\Delta\beta$	1	$+0''.032$
May 1	$x-.67+1.95=-.082-1.88$	1	$-.087$
3	$x-.66+1.96=+.119-1.75$	1	$+.112$
8	$x-.65+1.98=-.049-1.38$	1	$-.056$
Nov. 19	$x-.12-1.93=-.016+2.08$	1	$+.015$
22	$x-.11-1.91=+.043+1.58$	½	$+.073$
27	$x-.10-1.88=-.025+2.05$	½	$+.004$
29	$x-.09-1.86=+.010+1.77$	½	$+.039$
Dec. 8	$x-.06-1.75=-.103+1.98$	1	$-.078$
1889 May 9	$x+.35+1.98=+.025-1.56$	1	$-.022$
31	$x+.41+1.89=+.067-1.66$	1	$+.019$
June 3	$x+.42+1.85=+.054-1.58$	1	$+.006$

On November 22, 27, and 29 the observations were made with definition 3, and the corresponding equations have received half weight.

Having regard to the weights, the normal equations are :—

$$+10.50x-1.81y+7.03\pi=+0''.066-4.76\Delta\beta$$
$$-1.81+2.26-2.33=+0.048+1.95$$
$$+7.03-2.33+38.27=+0.507-34.82$$

Solving these normals and substituting the values of x, y, and π, we get the residuals given in the column headed O—C. The results are :—

$x=+0''.003+0.18\Delta\beta$;	weight 9·1 ;	probable error	$\pm0''.014$
$y=+0.040+0.04$;	„ 1·9 ;	„ „	±0.030
$\pi=+0.015-0.94$;	„ 32·9 ;	„ „	±0.007

$$[pvv]=0.0348 \qquad \frac{[pvv]}{n-3}=0.00386$$

and the probable error of a single observation of weight unity $\pm0''.042$.

The only remaining uncertainty in this result is the possible refraction effect, $\Delta\beta$, depending on the possible difference between the mean refrangibility of the light of *a Gruis* and that of the comparison stars.

As this effect, if at all sensible, must certainly depend on the difference between the types of the spectra of the principal star and the comparison star, it seems better to defer a discussion of the matter till the data referred to in a paper which I recently communicated to the Society (*Monthly Notices*, vol. lviii. p. 53) have been collected, and until I have access to the McClean telescope. The whole of this question, as it affects all these parallax researches, can then be dealt with on a broad and satisfactory basis. Meanwhile I venture to express the belief, founded on other considerations, that the value of $\Delta\beta$ will in this case not be found to amount to $0''\cdot01$.

It may interest the more casual reader to point out the great accuracy of the individual observations which the preceding results imply.

The probable error of the single observation of difference of two opposite distances is thus :—

For *Sirius* and comparison stars of $8\frac{3}{4}$ mag. $\pm 0''\cdot070$
„ *a Gruis* „ „ 8·0 mag. $\pm 0''\cdot042$

This implies that, as the result of one complete set of observations lasting less than an hour, the position of the principal star may be projected on the great circle joining two comparison stars with a probable error of

$\pm 0''\cdot035$ in the case of stars $8\frac{3}{4}$ mag.

or

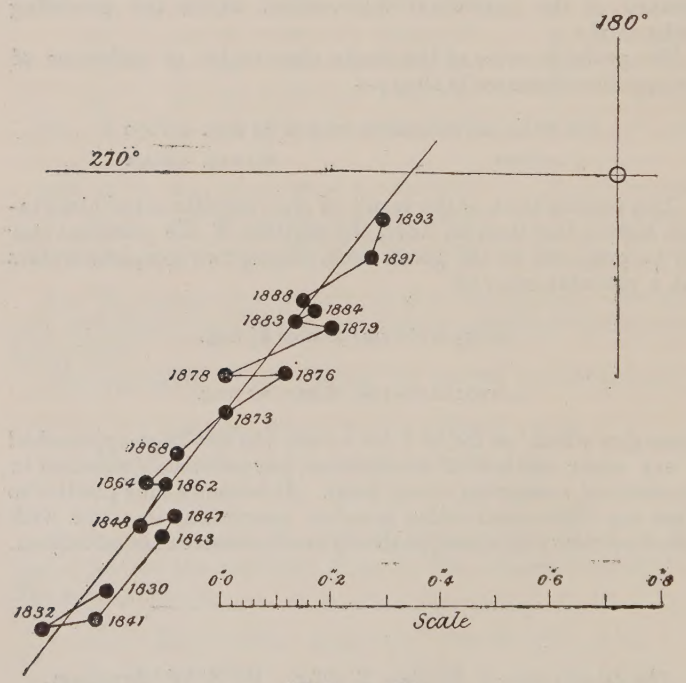
$\pm 0''\cdot021$ in the case of stars 8·0 mag.

a precision which, so far as I am aware, has not been approached by any other method of observation, nor previously attained in astronomical researches of any kind. It becomes thus possible to detect any differential stellar parallax amounting to $0''\cdot02$ with perfect certainty by a comparatively small number of observations.

The Double Star ζ Boötis. Σ 1865. By S. W. Burnham.

This double star was discovered by Herschel a little more than one hundred years ago (=H. N. 114). In his first observation, 1796 April 5, it is described as "very nearly in contact; I can, however, see a small division." On the following evening he measured the position-angle, which is given as $41'\ 59''$ *n.p.*

(*Mem. R.A.S.* vol. i.); but this appears from his diagram to be a misprint for 41° 59′, giving 312° for the position-angle as now reckoned. This is the value given by Herschel II. in the Synopsis of his father's double-star observations. On the last-mentioned date Herschel says, "With 460 a division is but barely visible $\frac{1}{4}$ of S" (referring to the diameter of the smaller star). His last observation was 1807 July 12, when he noted, "The interval between their apparent disks with 460 is $\frac{1}{3}$ of the diameter of either." The next observation appears to be by Amici in 1815 (*Zach. Corr. Astron.* vol. viii.), who measured the distance as 1″, but did not measure the angle. In 1823 South on one night measured both angle and distance, and made the latter 1″·68. He refers to Amici's distance as being "probably too small." The observations of Struve commence in 1827, and since that time this pair has been measured by most of the prominent double-star observers.



ζ Boötis. Σ 1865.

The earlier measures appeared to show little or no change, and Dawes, referring to the observations down to 1853, says: "Notwithstanding considerable discrepancies in the results, no

sufficient ground appears for suspecting relative motion. The oblique position of the components may in great measure account for the errors of observation, where no suitable precautions have been taken to avoid its effects." Since that time, however, the distance has steadily decreased, and it is now certain that the most reliable measures show a regular diminution in the distance during the entire interval. In later times it has generally been regarded as a binary of long period.

In an investigation of the character of the relative motion of these stars, it is certainly better to rely as far as possible upon the micrometrical results obtained by the most experienced observers in this field, and accordingly I have given on the diagram accompanying this paper a selection of the best measures, commencing with Struve. It will be seen from these positions that the apparent movement of the smaller component has no sensible variation from rectilinear motion. It is obvious that when this movement is not in the line of the principal star it must follow a curved path of some kind if the stars form a binary system, but the orbit might be such that the variation of the described arc from a right line could not be eliminated from the ordinary errors of observation in a pair of this class where the distance for the greater part of the time has been less than 1″.

Whether the change is due to the slow revolution of one star about the other, or to the proper motion of one or both components, the theory of rectilinear motion, at least down to the present time, will satisfy the observations with all desirable accuracy. An examination of the positions given shows that the companion star has moved 0″·89 in the direction of 142°·5 since 1831, or about 0″·0143 annually. It will be seen that these positions depend largely upon the distances alone. The change in the angle has been slow during nearly the whole interval, and the error in the measures upon any theory is therefore principally in the distances. The corrections to be applied to the observed distances in the measures shown on the diagram are as follows :—

1830·47	+0″·21	11*n*	Σ
1832·47	−0·05	3*n*	Da
1841·16	−0·10	6*n*	OΣ
1843·40	+0·07	7*n*	Ma
1847·72	+0·08	8*n*	OΣ
1848·11	−0·03	6*n*	Da
1862·95	−0·13	11*n*	OΣ
1864·78	−0·17	8*n*	Δ
1868·59	−0·16	8*n*	OΣ, Δ
1873·01	−0·12	4*n*	OΣ
1876·47	−0·03	8*n*	OΣ, Hl

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1878·48	−0″·14	2*n*	Δ
1879·04	+0·04	5*n*	Hl
1883·17	−0·06	3*n*	OΣ
1884·43	−0·03	3*n*	Hl
1888·54	−0·09	2*n*	OΣ
1891·31	+0·01	3*n*	β
1893·51	+0·03	5*n*	Lewis, Lv

For the most part, these corrections are as small as would be found generally in measures of a star of this class, and they cannot be materially lessened upon any other theory of motion. If the companion continues to move uniformly in the direction indicated, the minimum distance of 0″·29 will be reached about 1917.

The meridian observations of *ζ Boötis* show a small proper motion. Porter gives the annual movement as 0″·030 in the direction of 109°·6. As this star would be apparently single in all meridian instruments, this value would probably represent the mean of the two components. Taking it as the motion of the principal star, we have the following relation between the two :—

Proper motion of A	0″·030 in 109°·6
Proper motion of B	0″·043 in 119°·9

With uniform rectilinear motion, the distance between the two stars at the time of Herschel's observations in 1796 would be 1″·74, and this agrees well with his position-angle at that time. It would seem at first that his descriptions of this pair, as already mentioned, would call for a smaller distance than that given above ; but when we examine similar descriptions by Herschel of various stars of his Class I., where he has compared the distance between the components to the apparent diameter of one or the other of the stars, we find several instances where the distances at that time, as determined from the later history of the motion, could not have been less than 1″·7, so there is nothing in these early observations inconsistent with the theory of uniform motion. It will probably be a long time before the true relation of these stars is known with absolute certainty. At present it seems to belong to the 61 *Cygni* type of double stars, where the components are moving together in space, but with slightly different velocities and directions. We have now some forty or fifty of these pairs, and in most of them there is now little doubt of the relative change being entirely due to the difference of proper motion.

Yerkes Observatory :
December 13.

The Orbit of OΣ 400. By S. W. Burnham.

This close pair of the Pulkowa Catalogue, discovered by Otto Struve something more than half a century ago, was first measured by Mädler in 1843. The measures of OΣ commence in 1844, and continue at intervals down to 1861. It received special attention from Dembowski, who examined it on eleven nights 1865–77, and measured the angle whenever he could do so, but the distance was too small to be measured with his aperture. Since that time very few measures have been made. A large instrument has been necessary in recent years to show any measurable elongation.

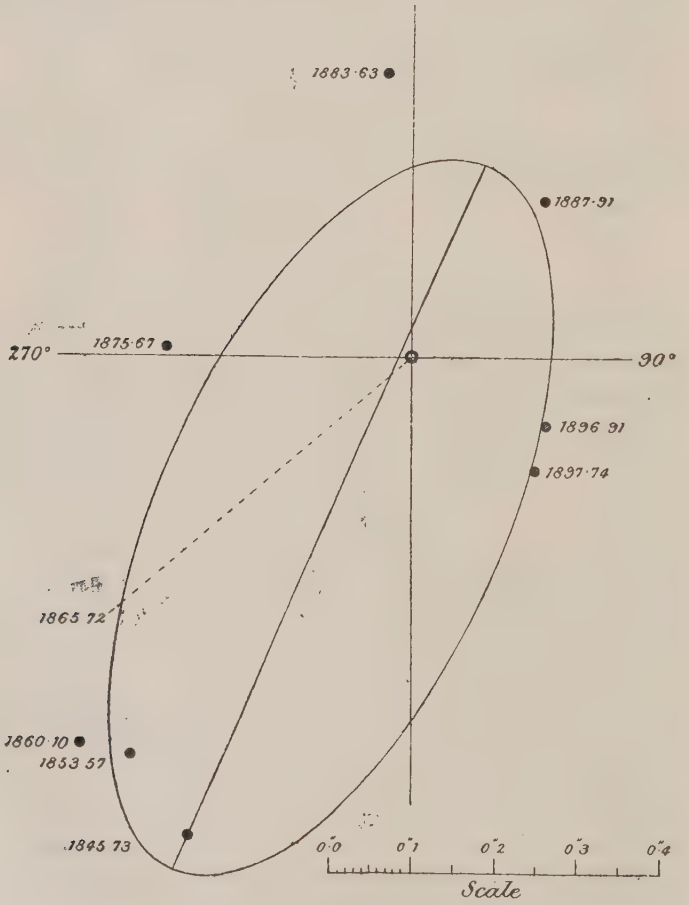
One orbit has been computed of this pair. Gore (*Monthly Notices*, xlvii. 346) from the positions to 1885 found a period of 170·37 years.

The following are all the observations of this pair :—

1843·39	326°·7	0″·5 ±	2*n*	Mädler
*1845·73	334·9	0·64	3*n*	O. Struve
*1853·25	324·6	0·59	2*n*	O. Struve
1853·89	320·5	0·65 ±	1*n*	Dawes
*1860·10	319·3	0·62	2*n*	O. Struve
*1865·72	310·7	...	2*n*	Dembowski
1868·55	301·6	obl.	1*n*	Dembowski
1871·04	301·2	oval	2*n*	Dembowski
1872·62	314·9	obl?	1*n*	Dembowski
1873·88	94·0?	obl?	2*n*	Dembowski
1874·50	107·8	obl?	1*n*	Dembowski
*1875·67	267·9	0·3 ±	3*n*	Schiaparelli
1877·59		Single	1*n*	Dembowski
1878·65		Single	1*n*	Burnham
1879·82	150·2	>0·5 ±	2*n*	Seabroke
1880·68		Single?	1*n*	Schiaparelli
1881·70		Single	1*n*	Bigourdan
1883·62		"not divided"	1*n*	Seabroke
*1883·63	185·3	0·35 ±	1*n*	Schiaparelli
1885·72	144·5	0·3 ±	2*n*	Young
1886·77	122·7	0·3 ±	1*n*	Hough
*1887·91	140·1	0·25 ±	1*n*	Schiaparelli
1892·79	300 ±	0·2 ±	1*n*	Comstock
1895·73	346·8	0·2 ±	2*n*	See
1895·76		Single	1*n*	Comstock

1896·66		Single	1*n*	Comstock
1896·90	67·8	0·18	2–1*n*	Hussey
*1896·92	63·5	0·18	3*n*	Aitken
*1897·74	47·3	0·20	3*n*	Aitken

It is evident that little use can be made of most of this material in investigating the character of the relative motion. Some of the positions are obviously erroneous or uncertain. With the recent measures made with the 36-in. at Mt. Hamilton we have a total arc of nearly 290°, which should give data for determining the elements of the orbit with substantial accuracy. The observations in the foregoing list marked (*) are shown on the accompanying diagram.



Orbit of OΣ 400.

From these positions the following elements are obtained :—

P	=	81·04 years
T	=	1888·23 „
e	=	0·46 „
a	=	0″·47 „
i	=	59°·9 „
☊	=	157°·1 „
λ	=	7°·0 „

Apparent orbit :—

Length of major axis... ...	0″·93
Length of minor axis... ...	0″·42
Angle of major axis	155°·9
Angle of periastron	153°·5
Distance of star from centre...	0″·21

The observed positions require the following corrections :—

1845·73	+ 0°·2	+0″·04	3*n*	O. Struve
1853·57	+ 2·8	+0·06	2*n*	O. Struve
1860·10	0·0	−0·05	2*n*	O. Struve
1865·72	+ 0·1	...	2*n*	Dembowski
1875·67	+ 2·1	−0·06	3*n*	Schiaparelli
1883·63	+ 2·8	−0·13	1*n*	Schiaparelli
1887·91	+15·5	0·00	1*n*	Schiaparelli
1896·91	− 5·2	0·00	3*n*	Aitken
1897·74	0·0	0·00	3*n*	Aitken

It will be noticed that most of these errors are insensible quantities in measures of a close pair of this kind. The distance is now slowly increasing, and in a few years it can be measured with a moderate aperture.

The magnitudes of the components, according to O. Struve, are 7·2 and 8·2. The principal star is Lalande 38758, and its place (1875) from the Bonn Catalogue is—

R. A.	20ʰ	6ᵐ	5ˢ
Decl.	43°	34′	23″

It does not appear to have any sensible proper motion.

Yerkes Observatory :
December 23.

The Ternary System, Lac 7215=h 4935. By R. T. A. Innes.

As a wide pair this was observed by Sir John Herschel at the Cape in 1837, and the chief star was noted as double at Melbourne in 1867, but it was first measured as a double star some years later as β 416 and Russell 298. The chief star turned out to be a rapid binary pair with a period of 33 years according to the orbit computed by Professor See. Of Herschel's companion, which is C Z $17^h{\cdot}719$, I find the following measures :—

		"		
1837·4	130° ±	...	*h*	1 night.
1875·5	130·5	29·44	Cord. Zone Catalogue.	1 ,,
1876·5	130 ±	,...	β	1 ,,
1877·6	132·4	,...	Russell	1 ,,
1889·4	128·6	31·03	β	3 ,,
1891·5	128·8	30·52	do.	3 ,,
1892·4	129·4	30·55	do.	2 ,,

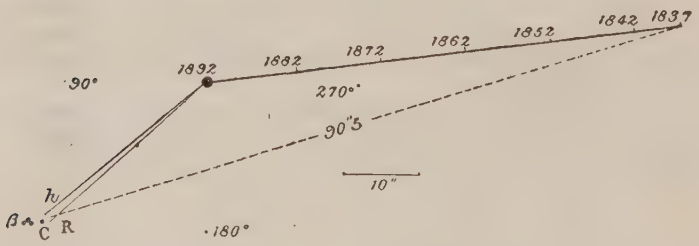
The chief star, which is yellow in colour, is *Lac* 7215 (R.A. $17^h\ 12^m\ 8^s$, Dec. 34° 52′·7, 1900), and has a large proper motion which is well known. The latest determination, that of Professor Porter, gives

$$\delta \text{ R.A.} = +0''{\cdot}0924. \qquad \delta \text{ Dec.} = -0''{\cdot}161$$

or

$$1''{\cdot}15 \text{ towards } 98°{\cdot}1,$$

The consideration of this proper motion shows that the Herschel companion travels with the binary pair.



The diagram will, perhaps, make the matter clearer. If both stars are animated by the same proper motion the position marked 1892 will be that of the chief star in relation to the measures of the companion, which are marked *h*, C, R, and β. The agreement is satisfactory.

If, however, the companion does not share in the proper

motion the chief star should have been found along the line marked 1892–1837.

Thus at the time of the Cordoba observation the distance, instead of being 29″ as observed, would have been about 50″, in the time of *h* about 90″, the angles as well being altered.

If we assume the mass of the close pair equal to that of the Sun, its parallax will be 0″·12 ; and if we now see the third star under an angle equal to its semi-axis major, its period of revolution would not be greatly different from 4,000 years.

The magnitudes of the three stars are 6·1, 8·1, and 10; but it is well to state that for the latter, estimates vary from 7 to 12—viz.

Gould	... 9·5
Russell	... 7·0
Burnham	... 10 to 12.

Royal Observatory, Cape of Good Hope:
1897 December 3.

The Wilsonian Theory and Mr. Howlett's Drawings of Sun-spots.

By the Rev. Aloysius L. Cortie, S.J.

In Dr. Wilson's paper entitled "Observations on the Solar Spots" (*Phil. Trans. R.S.* vol. lxiv. A.D. 1774), in which his theory with regard to the cavernous nature of Sun-spots relatively to the photospheric level is propounded, he particularly calls attention to the fact that the phenomenon of the unequal foreshortening of the penumbra on either side of the umbra (or umbra and nucleus in his phraseology) is only to be observed in those spots which are not subject to any disturbance, the appearances to be expected under normal conditions being sometimes counteracted when changes have occurred in the spots during their transit across the solar disc. The Wilsonian hypothesis has lately been called in question by the Rev. Mr. Howlett, whose contention is that the Sun-spots are in general elevations above rather than depressions below the photospheric level. The admirable series of enlarged drawings of the solar spots made by this indefatigable observer have been most generously presented to the Society, and are preserved in our library. From an examination of many of these drawings it would seem that the rule that has guided Mr. Howlett in the selection of his cases against the Wilsonian hypothesis is that any spot in the neighbourhood of the limb which shows the penumbra of greater extent on the side towards the centre of the Sun is a case against the cavernous theory of the spots. In the remarks in the index which precedes each volume such expressions sometimes occur as " seemed to favour Wilson, but umbra not central and the group

actively changing." But if spots that seemingly tell for the Wilsonian theory are to be rejected and put out of court for these reasons, surely the same reasons are equally cogent in cases which tell against the theory. In fact, as Father Sidgreaves has well pointed out in his paper on this subject (*Monthly Notices R.A.S.* vol. lv. No. 5, 1895 March), no spot ought to be admitted as a suitable test in the present controversy in which the following conditions are not verified : "(1) That the spot had been observed at a position approximately between 30″ and 60″ of arc from either limb ; (2) that it had been watched on its passage between the central meridian and the limb ; (3) that it was a compact regular spot ; (4) that it showed a central umbra when remote from the limb ; and (5) that it was a quiet spot, not indicating a tendency to divide or change shape."

As the careful examination of so large a number of spots as Mr. Howlett has drawn would have taken a considerable amount of time, a volume was selected at haphazard, and the spots which are chronicled as against Wilson for the year 1883 were studied in detail. They are thus indexed :—

No.	Spot.	Date (1883).
313	η	Apr. 20
314	σ	May 11
316	ψ	June 3
317	u	June 4
320	ξ	July 18
321	β	June 30
329	ω	Sept. 4
330	ι and ζ	Sept. 8
335	δ and ϵ	Oct. 17

Eleven cases, therefore, are furnished for examination, and of these the spots 313 η and 316 ψ have no life histories recorded in Mr. Howlett's drawings, and hence it is impossible to say whether they should be admitted as test cases. A reference to the Stonyhurst drawings of these groups is against their admission, on account of their disturbed nature. The spot 314 σ, too, showed great changes between May 17 and 18, as can be seen from the sheet 315, and must be excluded from the discussion. Spot 317 u must also be rejected on account of the disturbances registered on June 3 and 4. The spot 320 ξ in the enlarged drawing made at 7.30 A.M. on July 18 is seen to be of a broken outline with bright patches in the penumbra ; and on the 21st, when nearly central, shows penumbra on one side only, and that the inner side from the Sun's centre. The next spot, 321 β, underwent a period of disturbance between June 25 and 29. With regard to 329 ω it is depicted as a black line nearly on the limb, but so hazy and ill-defined that it is impossible to determine whether it be composed of umbra or penumbra. There is no

enlarged drawing of the spot on the previous day, but on August 26 an enormous extent of faculæ is recorded on the preceding limb. From the drawings, too, it would appear that this spot is identical with the spot ϵ of August 23 and 26; and if so, between these two dates the umbra had separated into three parts, with a great change in the penumbra. The spots 330 ι and ζ must likewise be rejected as being disturbed spots, and moreover in the case of the first the umbra was not centrally placed with regard to the penumbra. As to the disturbed nature of the spots, the evidence furnished by the drawings with regard to the first is that on September 8, at 4.30 P.M., it had two nuclei which had coalesced into one by 8 A.M. the next morning; while with regard to the latter its nucleus on September 3 was long and compact; on September 4 it showed evident signs of breaking up; and when on the limb on September 8 the S. part of the spot was composed of penumbra which corresponded to the penumbral tail of September 3 and 4. Of the group 335 δ and ϵ the latter spot was of irregular outline, with scattered umbra and penumbra on October 13, and two days after a portion on the preceding side was detached from it. Again on October 17 there was much faculæ near the limb, and, as Secchi has pointed out, the presence of faculæ in the region of a spot frequently counteracts the appearance it would present were it a cavity; and moreover in this case the spot, if admitted at all, would seem to tell rather for than against the depression hypothesis. There remains the group 335 δ, which on October 13 consisted of four spots, two of them—and these the more northerly—being irregular and disturbed, and two being of more constant outline. Of these two again one had not the umbra central on October 13, but the penumbra was much more extensive on the inner side than on the outer side, and hence when foreshortened apparently told against Wilson's view. There remains but one spot to be dealt with, and that is the most southerly of the whole group. On October 13 the umbra extended rather in the E. and W. direction, the penumbra being more extensive on the N. than on the S. of the spot. On October 15 the umbra is represented as lying more in the N. and S. direction, as if the spot had partly turned on its axis. On October 17 the penumbra is about equal on each side of the umbra, instead of being less on the inner side, and so far is against Wilson.

From this discussion of the individual cases quoted it would appear that the witness of all these spots, with one possible exception, must be rejected. The study of these cases was made from Mr. Howlett's drawings, without any reference to, or help from, other drawings or photographs, so as to avoid all bias and prejudice. Subsequently, however, all the above spots were studied on the Stonyhurst drawings, with the exception of 329 ω, and of part of the group 330 ι and ζ, of which we have no record. In every case the description of the spots given above is fully

LEEDS PHILOSOPHICAL AND LITERARY SOCIETY.

corroborated, and the only spot which can possibly tell against the Wilsonian hypothesis is the most southerly member of the group 335, which on October 17 was about 25″ of arc from the preceding limb of the Sun. The evidence of this one spot is reliable, but by no means weighty, as adverse to the depression hypothesis.

Among the cases of Sun-spots indexed by Mr. Howlett (vol. vii.) as "decidedly adverse to Wilson" are two dated 1887 July 4 and July 6. The evidence of the Stonyhurst drawings with reference to these examples can be studied in Plate 7 of the *Memoirs R.A.S.* vol. xlix. p. 286, illustrating Father Perry's paper on "Photographs and Drawings of the Sun." Group 4 of the plate corresponds to Mr. Howlett's first case, and it will be seen on reference to the series of reproductions of the drawings, which are somewhat smaller in size than the originals, that on July 3–4, when the spot is near the following solar limb, the evidence is apparently against Wilson, but on the 14th, when near the preceding limb, it is much more strongly, seemingly, in his favour. But it will be noticed that the evidence is weakened by the drawing on the 13th, and from the shifting of and changes in the umbra from day to day as the spot crossed the limb. If the spot is to be regarded as a test case, then as far as the Stonyhurst drawings bear witness it cannot be said to be "decidedly against Wilson," but rather in his favour. This case was rejected as unreliable in the discussion of the bearing of the Stonyhurst series of drawings on the Wilsonian hypothesis. With regard to the spot dated 1887 July 6, group 3 of the plate shows a spot which is in favour of the depression theory when on the preceding limb, and this cannot be the spot referred to. But in group 5 we can study two normal spots as they cross the disc, and of these the first is against Wilson's theory on the 6th, but again for the theory when on the preceding limb on the 17th; while the second one, though a small spot, is against Wilson both on the 6th and 17th. The reproduction of the 18th is not quite correct; the original is against Wilson. Hence it appears that the Stonyhurst drawings bear out Mr. Howlett's contention in one of his two "decided" cases, and that only partially. But there is one set of drawings—those, namely, which constitute group 2 of the same plate—which is a very strong case against the Wilsonian view. Father Sidgreaves has already called attention to this example, in his paper before referred to, as indicating rather a mountainous than a cavernous form of umbra in the spot.

It would appear, then, from this detailed examination of some of the cases adduced by Mr. Howlett that their evidence is by no means conclusive against the Wilsonian theory. On the other hand it must be admitted that the phenomena presented by many spots are directly contrary to the theory, and from a careful study of these on the Stonyhurst drawings Father Sidgreaves has been led (*loc. cit.*, p. 286) to a partial confirmation of Mr. Howlett's adverse criticism. To the writer it seems, without contesting in

any way or expressing any opinion upon the theory advocated in opposition to the depression hypothesis of Sun-spots, that the strength of the position taken up by Mr. Howlett is not warranted by his drawings, and that the weight of the negative evidence derived from them must be modified.

Stonyhurst College Observatory:
1898 *January* 14.

Observations of Occultations of Stars by the Moon and of Phenomena of Jupiter's Satellites made at the Royal Observatory, Greenwich, in the year 1897.

(Communicated by the Astronomer Royal.)

Day	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
Apr. 15	Disapp. W.B. XII. 334	Astrographic Equat.	225	Dark	11 32 38·24	J.
May 4	Reapp. Piazzi IV. 287	Altazimuth	100	Bright	8 38 0·98	H.
4	Disapp. W.B. (2) IV. 1358–9	,,	100	Dark	8 39 49·58	,,
6	,, W.B. (2) VI. 1452	,,	100	,,	9 36 31·67	A. C.
6	,, W.B. (2) VI. 1447	Sheepshanks Equat.	100	,,	9 38 30·78	J.
June 18	,, Piazzi XXI. 291	,,	100	Bright	13 42 37·24	S.
18	Reapp. ,,	,,	100	Dark	14 10 47·50	,,
July 11 (*a*)	,, Lalande 31226	Astrographic Equat.	225	Bright	9 6 41·95	W.
13	Disapp. χ^1 Sagittarii	Sheepshanks Equat.	55	Dark	9 21 4·17	B.
13	,, ,,	Altazimuth	100	,,	9 21 4·27	S.
13	,, ,,	Astrographic Equat.	225	,,	9 21 3·87	W. S.
13 (*b*)	Reapp. ,,	Sheepshanks Equat.	225	Bright	10 22 (10·20)	B.
13	,, ,,	Altazimuth	100	,,	10 22 7·82	S.
23	Disapp. 17 Tauri	Astrographic Equat.	225		12 17 2·78	C. D.
23	,, ,,	Sheepshanks Equat.	100	,,	12 17 (0·09)	W. S.
23	,, 16 Tauri	Astrographic Equat.	120	,,	12 40 35·43	C. D.
23	Reapp. ,,	,,	120	Dark	12 53 29·52	,,

Day.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
July 23	Reapp. 16 Tauri	Sheepshanks Equat.	100	Dark	12 53 29·89	W. S.
23	Disapp. 23 Tauri	Astrographic Equat.	120	Bright	12 55 15·53	C. D.
23	,, ,,	Sheepshanks Equat.	100	,,	12 55 14·80	W. S.
23 (*a*)	,, Piazzi III. 135	Astrographic Equat.	225	,,	12 58 53·44	C. D.
23 (*a*)	,, B.D. + 23° No. 523	,,	225	,,	13 1 9·07	,,
23	Reapp. 17 Tauri	,,	120	Dark	13 10 4·51	,,
23	,, ,,	Corbett Tel.	100	,,	13 10 3·72	H. F.
23	,, ,,	28-inch Equat.	670	,,	13 10 3·52	S.
23	,, W.B. (2) III. 812	Astrographic Equat.	120	,,	13 10 57·47	C. D.
23	,, Piazzi III. 135	,,	120	,,	13 19 24·29	,,
23	,, ,,	Sheepshanks Equat.	100	,,	13 19 (25·83)	W. S.
23	,, B.D. + 23° No. 510	Astrographic Equat.	120	,,	13 22 13·63	C. D.
23	Disapp. η Tauri	,,	120	Bright	13 22 45·74	,,
23	,, ,,	Corbett Tel.	100	,,	13 22 46·41	H. F.
23	,, ,,	28-inch Equat.	670	,,	13 22 46·41	S.
23	,, ,,	Sheepshanks Equat.	100	,,	13 22 46·28	W. S.
23	,, Piazzi III. 151	Corbett Tel.	100	,,	13 26 46·13	H. F.
23	,, ,,	28-inch Equat.	670	,,	13 26 46·73	S.
23	Reapp. B.D. + 23° No. 513	Astrographic Equat.	225	Dark	13 28 36·58	C. D.
23	,, B.D. + 23° No. 517	,,	120	,,	13 32 30·95	,,

Day.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
July 23	Reapp. 23 Tauri	Corbett Tel.	100	Dark	13 32 29·37	H. F.
23	,, ,,	28-inch Equat.	670	,,	13 32 29·17	S.
23	,, W.B. (2) III. 845	Corbett Tel.	100	,,	13 47 51·60	H. F.
23	,, ,,	28-inch Equat.	670	,,	13 47 51·20	S.
23	,, W.B. (2) III. 846	Astrographic Equat.	120	,,	13 48 51·36	C. D.
23	,, ,,	Corbett Tel.	100	,,	13 48 51·32	H. F.
23	,, ,,	28-inch Equat.	670	,,	13 48 50·82	S.
23	,, ,,	Sheepshanks Equat.	100	,,	13 48 (52·47)	W. S.
23	,, B.D. + 23° No. 528	Astrographic Equat.	120	,,	13 52 34·76	C. D.
23	,, ,,	Corbett Tel.	100	,,	13 52 35·21	H. F.
23	,, ,,	Sheepshanks Equat.	100	,,	13 52 34·36	W. S.
23	,, B.D. + 23° No. 523	Astrographic Equat.	120	,,	13 54 15·68	C. D.
23	,, ,,	Corbett Tel.	100	,,	13 54 15·62	H. F.
23	,, ,,	28-inch Equat.	670	,,	13 54 14·62	S.
23	,, B.D. + 23° No. 526	Astrographic Equat.	120	,,	13 55 40·15	C. D.
23	,, B.D + 23° No. 531	,,	120	,,	14 12 17·44	,,
23	,, ,,	Corbett Tel.	100	,,	14 12 16·61	H. F.
23	,, ,,	Sheepshanks Equat.	100	,,	14 12 17·11	W. S.
23	,, 24 Tauri	Astrographic Equat.	120	,,	14 13 4·31	C. D.
23	,, ,,	Corbett Tel.	100	,,	14 13 3·57	H. F.

Day.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
July 23	Reapp. 24 Tauri	28-inch Equat.	670	Dark	14 13 4·87	S.
23	,, ,,	Sheepshanks Equat.	100	,,	14 13 3·98	W. S.
23	,, B.D. + 23° No. 534	Astrographic Equat.	120	,,	14 14 14·03	C. D.
23 (*c*)	,, ,,	Corbett Tel.	100	,,	14 14 (16·59)	H. F.
23	,, η Tauri	Astrographic Equat.	120	,,	14 15 3·98	C. D.
23	,, ,,	Corbett Tel.	100	,,	14 15 3·04	H. F.
23	,, ,,	28-inch Equat.	670	,,	14 15 2·44	S.
23	,, ,,	Sheepshanks Equat.	100	,,	14 15 3·65	W. S.
23	Disapp. 28 Tauri	Astrographic Equat.	120	Bright	14 17 22·40	C. D.
23 (*a*)	,, ,,	Corbett Tel.	100	,,	14 17 (19·45)	H. F.
23	,, ,,	28-inch Equat.	670	,,	14 17 21·55	S.
23	Reapp. Piazzi III. 151	Astrographic Equat.	120	Dark	14 24 50·29	C. D.
23	,, ,,	Corbett Tel.	100	,,	14 24 49·81	H. F.
23	,, ,,	28-inch Equat.	670	,,	14 24 49·81	S.
23	,, ,,	Sheepshanks Equat.	100	,,	14 24 49·75	W. S.
23	,, B.D. + 23° No. 548	Astrographic Equat.	120	,,	14 32 59·85	C. D.
23 (*a*)	Disapp. Piazzi III. 164	Corbett Tel.	100	Bright	14 33 17·59	H. F.
23	,, ,,	28-inch Equat.	670	,,	14 33 18·29	S.
23	Reapp. B.D. + 23° No. 549	Astrographic Equat.	120	Dark	14 46 44·31	C. D.
23	,, ,,	Corbett Tel.	100	,,	14 46 45·85	H. F.
23	,, ,,	28-inch Equat.	670	,,	14 46 45·35	S.
23	,, B.D. + 23 No. 554	Astrographic Equat.	120	,,	14 47 31·78	C. D.
	,, ,,	Corbett Tel.	100	,,	14 47 31·81	H. F.

Day.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
July 23	Reapp. B.D. + 23 No. 554	28-inch Equat.	670	Dark	14 47 31·71	S.
23	,, 28 Tauri	Astrographic Equat.	120	,,	14 52 45 13	C. D.
23	,, ,,	Corbett Tel.	100	,,	14 52 44·84	H. F.
23	,, ,,	28-inch Equat.	670	,,	14 52 44·84	S.
23	,, Bradley 523	Corbett Tel.	100	,,	14 55 35·36	H. F.
23	,, ,,	28-inch Equat.	670	,,	14 55 33·86	S.
23	,, B.D. + 23° No. 562	Astrographic Equat.	120	,,	15 14 26·19	C. D.
23	,, ,,	Corbett Tel.	100	,,	15 14 25·52	H. F.
23	,, ,,	28-inch Equat.	670	,,	15 14 24·32	S.
23	,, ,,	Sheepshanks Equat.	100	,,	15 14 24·90	W. S.
23	,, B.D. + 23° No. 560	Astrographic Equat.	120	,,	15 19 52·20	C. D.
23	,, ,,	Corbett Tel.	100	,,	15 19 51·20	H. F.
23	,, ,,	28-inch Equat.	670	,,	15 19 50·80	S.
23	,, W.B. (2) III. 903	Astrographic Equat.	120	,,	15 21 53·57	C. D.
23	,, ,,	Corbett Tel.	100	,,	15 21 52·47	H. F.
23	,, ,,	28-inch Equat.	670	,,	15 21 52·17	S.
23	,, ,,	Sheepshanks Equat.	100	,,	15 21 53·46	W. S.
23 (*d*)	,, Piazzi III. 164	Corbett Tel.	100	,,	15 36 36·80	H. F.
23	,, ,,	28-inch Equat.	670	,,	15 36 36·00	S.
Aug. 4	Disapp. 89 Virginis	Altazimuth	100	,,	8 17 0·81	H.
Oct. 3	,, χ^2 Sagittarii	Sheepshanks Equat.	125	,,	6 41 59·42	W.
3	,, χ^1 Sagittarii	Astrographic Equat.	225	,,	6 42 59·57	R. C.

Day.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
Oct. 3	Disapp. χ^1 Sagittarii	Sheepshanks Equat.	125	Dark	6 42 59·35	W.
3	Reapp. ,,	,,	125	Bright	7 33 59·57	,,

Notes.

(*a*) Not considered a good observation.
(*b*) Seemed to be a slight distance from limb when first seen.
(*c*) The observer noted that the observed time was probably late.
(*d*) Observed in twilight. The observed time has been diminished by one minute.

Phenomena of Jupiter's Satellites.

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of *N.A.* h m	Observer.
1897.							
Jan. 27	I. (*a*)	Tr. Ing. First contact	E. Equat.	120	9 6 56·41		H.
27	I.	Bisection	,,	,,	9 9 1·07	9 10	,,
27	I.	Last contact	,,	,,	9 11 15·7		,,
27	I.	Tr. Egr. Bisection	,,	,,	11 28 13·34		,,
27	I.	Last contact	,,	,,	11 30 8·03	11 29	,,
28	II.	Tr. Ing. Bisection	,,	,,	9 53 48·53		A. C.
28	II.	Last contact	,,	,,	9 55 33·24	9 55	,,
28	II.	Tr. Egr. First contact	,,	,,	12 38 37·58		,,
28	II.	Bisection	,,	,,	12 40 43·24	12 45	,,
28	II.	Last contact	,,	,,	12 42 23·96		,,
Mar. 13	I. (*b*)	Occ. D. First contact	,,	,,	11 7 45·23		W. B.
13	I.	Bisection	,,	,,	11 9 10·00	11 9	,,
13	I.	Last seen	,,	,,	11 10 24·80		,,

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of *N.A.* h m s	Observer.
Mar. 22	I.	Ecl. R. First seen	Transit Circle	195	10 15 0·81	10 14 55	H. F.
22	I.	Bisection	,,	,,	10 16 5·62		,,
30	I. (*c*)	Sh. Egr. First contact	Astrog. Equat.	225	9 27 17·68	9 32	C. D.
30	I.	Last contact	,,	,,	9 31 12·03		
30	III.	Tr. Ing. First contact	,,	,,	9 41 55·27		,,
30	III.	Bisection	,,	,,	9 45 9·74	9 44	,,
30	III.	Last contact	,,	,,	9 49 58·96		,,
Apr. 14	I.	Ecl. R. Full brightness	E. Equat.	200	10 29 8·01	10 27 33	H.
18	II.	Ecl. R. First seen	Astrog. Equat.	225	11 0 46·31	11 0 24	H. F.
18	II.	Bisection	,,	,,	11 2 6·08		,,
18	II.	Full brightness	,,	,,	11 4 0·77		,,
28	I.	Occ. D. Bisection	E. Equat.	120	10 50 13·36	10 50	B.
28	I.	Last seen	,,	,,	10 51 33·13		
May 20	II.	Ecl. R. First seen	,,	,,	10 40 37·06	10 39 38	W.
20	II.	Bisection	,,	,,	10 41 56·84		,,
20	II.	Full brightness	,,	,,	10 43 56·51		,,

Notes.

(*a*) Bad definition. (*b*) Thin cloud over *Jupiter*. (*c*) Definition very poor.

The initials H., A. C., B., C. D., W. B., H. F., R. C., J., S., W., W. S., are those of Mr. Hollis, Mr. Crommelin, Mr. Bryant, Mr. Davidson, Mr. Bowyer, Mr. Furner, Mr. Cheeseman, Mr. Johns, Mr. Showell, Mr. Witchell, and Mr. Stevens respectively.

Occultations of the Pleiades by the Moon on 1897 July 23 and 1898 January 3, observed at the Radcliffe Observatory, Oxford.

(*Communicated by the Radcliffe Observer.*)

The following are observations of two occultations of the Pleiades by the Moon, viz. on 1897 July 23 and 1898 January 3 :—

	Name of Star.	Magnitude.	Phenomenon.	Moon's Limb.	Observer.	Instrument.	Power.	Time Noted.	Oxford Sidereal Time.	Greenwich Mean Time.	Ref. No.
1897.								h m s	h m s	h m s	
July 23	17 Tauri	3·8	Disapp.	Bright	R.	Barclay Equat.	85	20 18 45·5	20 21 3·12	12 18 8·5	(1)
	16 Tauri	6·5	Reapp.	Dark	R.	,,	85	20 51 36·0	20 53 53·74	12 50 53·8	(2)
	17 Tauri	3·8	,,	,,	R.	,,	45	21 11 24·9	21 13 42·71	13 10 39·5	...
	Arg. Z + 23°·536	6·8*	Disapp.	Bright	R.	,,	45	21 19 48·	21 22 5·84	13 19 1·2	(3)
	η Tauri	3 0	,,	,,	R.	,,	45	21 23 57·7	21 26 15·54	13 23 10·3	(4)
	Arg. Z + 23°·540	7·0*	,,	,,	R.	,,	45	21 28 25·	21 30 42·86	13 27 36·8	(5)
	Arg. Z + 23°·517	8·0*	Reapp.	Dark	R.	,,	45	21 33 52·	21 36 30·72	13 33 23·8	(6)
	23 Tauri	4·2	,,	,,	R.	,,	45	21 34 26·7	21 37 5·42	13 33 58·4	(7)
	Arg. Z + 23°·536	6·8*	,,	,,	R.	,,	45	22 13 37·3	22 16 16·15	14 13 2·7	...
	η Tauri	3·0	,,	,,	R.	,,	45	22 14 28·0	22 17 6·85	14 13 53·2	(8)
	28 Tauri	6·2	Disapp.	Bright	R.	,,	45	22 17 6·	22 19 44·86	14 16 30·8	(9)
	28 Tauri	6·2	Reapp.	Dark	R.	,,	45	22 54 59·5	22 57 38·50	14 54 18·2	(10)
1898.											
Jan. 3	17 Tauri	3·8	Disapp.	Dark	W.	Heliometer	80	2 1 29·2	2 1 15·32	7 12 35·8	(11)

	Name of Star.	Magnitude.	Phenomenon.	Moon's Limb.	Observer.	Instrument.	Power.	Time Noted.	Oxford Sidereal Time.	Greenwich Mean Time.	Ref. No.
1898.								h m s	h m s	h m s	
Jan. 3	17 Tauri	3·8	Disapp.	Dark	R.	Barclay Eq.	85	2 1 29·0	2 1 15·24	7 12 35·7	(12)
	Arg. Z + 23°·510	8·1*	,,	,,	W.	Heliometer	80	2 12 58·3	2 12 44·41	7 24 3·0	(13)
	,,	,,	,,	,,	R.	Barclay Eq.	85	2 12 58·0	2 12 44·27	7 24 2·8	(14)
	Arg. Z + 23° 517	8 0*	,,	,,	W.	Heliometer	80	2 28 30·2	2 28 16·31	7 39 32·3	(15)
	,,	,,	,,	,,	R.	Barclay Eq.	85	2 28 29·8	2 28 16·13	7 39 32·2	(16)
	23 Tauri	4·2	,,	,,	W.	Heliometer	80	2 47 52·8	2 47 38·89	7 58 51·7	(17)
	,,	,,	,,	,,	R.	Barclay Eq.	85	2 47 52·5	2 47 38 88	7 58 51·7	(18)
	Arg. Z + 23°·519	8·2*	,,	,,	W.	Heliometer	80	2 53 1·2	2 52 47·28	8 3 59·3	...
	,,	,,	,,	,,	R.	Barclay Eq.	85	2 53 0·0	2 52 46·39	8 3 58·4	(19)
	Arg. Z + 23°·520	8·4*	,,	,,	W.	Heliometer	80	2 53 30·5	2 53 16·58	8 4 28·5	...
	,,	,,	,,	,,	R.	Barclay Eq.	85	2 53 30·5	2 53 16·89	8 4 28·8	(20)
	Arg. Z + 23°·523	7·4*	,,	,,	R.	,,	85	3 8 26 4	3 8 12·83	8 19 22·3	(21)
	17 Tauri	3·8	Reapp.	Bright	W.	Heliometer	80	3 14 25·	3 14 11·07	8 25 19·6	(22)
	Arg. Z + 23°·536	6·8*	Disapp.	Dark	R.	Barclay Eq.	85	3 27 5·0	3 26 51·49	8 37 57·9	(23)
	η Tauri	3·0	,,	,,	W.	Heliometer	80	3 32 8·2	3 31 54·25	8 42 59·8	(24)
	,,	,,	,,	,,	R.	Barclay Eq.	85	3 32 6·75	3 31 53 26	8 42 58·9	(25)
	23 Tauri	4·2	Reapp.	Bright	W.	Heliometer	80	3 59 7·	3 58 53·02	9 9 54·2	...
	28 Tauri	6·2	Disapp.	Dark	W.	,,	80	4 40 48·0	4 40 34·00	9 51 28 4	...

	Name of Star.	Magnitude.	Phenomenon.	Moon's Limb.	Observer.	Instrument.	Power.	Time Noted.	Oxford Sidereal Time.	Greenwich Mean Time.	Ref. No.
1898.								h m s	h m s	h m s	
Jan. 3	28 Tauri	6·2	Disapp.	Dark	R.	Barclay Eq.	85	4 40 47·3	4 40 34·01	9 51 28·4	(26)
	27 Tauri	3·8	,,	,,	W.	Heliometer	80	4 46 8·15	4 45 54·14	9 56 47·6	(27)
	,,	,,	,,	,,	R.	Barclay Eq.	45	4 46 7·15	4 45 53·87	9 56 47·4	...
	η Tauri	3·0	Reapp.	Bright	W.	Heliometer	80	4 55 43·5	4 55 29·48	10 6 21·4	(28)
	,,	,,	,,	,,	R.	Barclay Eq.	45	4 55 39·	4 55 25·75	10 6 17·7	(29)

The magnitudes given above are taken from the *N.A.*, or when marked with an asterisk from the Berlin (B) A.G. Catalogue.

Observers' Remarks.

(1) Gradual disappearance. (2) Instantaneous. (3) Merest speck at disappearance. (4) Good. (5) Faint. (6) Angle from vertex about 280°. (7), (8) Instantaneous. (9) Gradual disappearance. (10), (11) Instantaneous. (12) Good; instantaneous. (13), (15) In the same parallel and of nearly equal magnitude. (14), (16) Good; instantaneous. (17) Good. (18) Instantaneous; fairly good. (19) Fairly good; colour reddish. (20) Fairly good; magnitude estimated 0·2 fainter than (19). (21) Good. (22) May be a second late, not more. (23) Good; instantaneous. (24) Instrument had just been moved in R.A. to correct the diurnal movement when disappearance occurred. (25), (26) Good; instantaneous. (27), (28) Good. (29) Good; image of star very small; thin film of frost on object glass.

A ground fog prevailed during the occultations of 1898 January 3, and was at times rather dense.

The Barclay Equatorial is situated $0^s{\cdot}4$ west of the heliometer.

Observers:—W., Mr. W. Wickham; R., Mr. W. H. Robinson.

Radcliffe Observatory, Oxford:
1898 *January* 10.

Ephemeris for Physical observations of

(Continued from

Greenwich Noon.	P	L−O	B	Apparent Diameter. Equat. $2a$.	Defect.	Polar $2b$.	d	w	B′
1898.	°	°	°	″	″	″	°	°	°
Mar. 2	25·041	52·726	−2·697	44·07	0·07	41·30	4·62	264·8	−2·88
4	25·057	52·514	2·695	44·20	·06	41·43	4·26	264·4	2·87
6	25·073	52·294	2·693	44·32	·05	41·55	3·89	263·9	2·87
8	25·089	52·067	2·690	44·43	·04	41·65	3·51	263·3	2·87
10	25·105	51·834	2·687	44·54	·03	41·75	3·13	262·5	2·87
12	25·122	51·595	2·683	44·64	·02	41·84	2·74	261·6	2·86
14	25·139	51·350	2·678	44·72	·02	41·92	2·35	260·7	2·86
16	25·156	51·102	2·673	44·78	·01	41·98	1·96	259·1	2·85
18	25·172	50·851	2·667	44·84	·01	42·03	1·56	256·5	2·85
20	25·188	50·596	2·661	44·88	·00	42·07	1·17	252·7	2·84
22	25·203	50·339	2·654	44·92	·00	42·11	0·79	245	2·83
24	25·218	50·081	2·647	44·95	·00	42·13	0·43	224	2·82
26	25·233	49·823	2·639	44·95	·00	42·13	0·30	163	2·82
28	25·247	49·564	2·631	44·95	·00	42·13	0·58	120	2·81
30	25·261	49·307	2·622	44·92	·00	42·11	0·97	106 6	2·80
Apr. 1	25·274	49·052	−2·613	44·89	0·01	42·08	1·35	101·2	−2·79
3	25·287	48·798	2·604	44·85	·01	42·04	1·74	98·2	2·78
5	25·299	48·548	2·594	44·80	·02	42·00	2·14	96·1	2·77
7	25·311	48·301	2·583	44·74	·02	41·94	2·53	94·7	2·76
9	25·322	48·059	2·572	44·66	·03	41·86	2·92	93·80	2·75
11	25·332	47·822	2·561	44·58	·04	41·78	3·31	92·99	2·73
13	25·341	47·590	2·550	44·47	·05	41·69	3·69	92·35	2·72
15	25·350	47·364	2·539	44·36	·06	41·58	4·06	91·86	2·71
17	25·359	47·146	2·528	44·25	·07	41·48	4·44	91·50	2·70
19	25·367	46·937	2·517	44·12	·08	41·35	4·79	91·20	2·68
21	25·374	46·733	2·505	43·97	·09	41·22	5·15	90·95	2·67
23	25·381	46·537	2·493	43·82	·10	41·07	5·50	90·71	2·66
25	25·387	46·351	2·481	43·67	·11	40·94	5·83	90·50	2·65
27	25·392	46·174	2·469	43·50	·13	40·78	6·16	90·31	2·63
29	25·397	46·007	2·457	43·33	·14	40·61	6·48	90·14	2·62
May 1	25·402	45·851	−2·445	43·15	0·15	40·45	6·79	89·99	−2·61
3	25·406	45·705	2·434	42·96	·16	40·27	7·08	89·85	2·60
5	25·410	45·570	2·423	42·77	·17	40·09	7·37	89·72	2·58
7	25·413	45·446	2·412	42·57	·19	39·90	7·64	89·59	2·57
9	25·416	45·333	−2·401	42·36	0·20	39·71	7·91	89·47	−2·56

Jupiter, 1898. By A. C. D. Crommelin.

page 31.)

Greenwich Noon. 1898.	Longitude of Ⅱ's Central Meridian. 877°·90 I.	870°·27 II.	Corr. for Phase.	Light-time	A−O	B
	°	°	°	m	°	°
Mar. 2	140·13	226·80	+0·09	37·80	48·108	−2·286
4	96·20	167·62	·08	37·69	48·259	2·292
6	52·29	108·44	·07	37·58	48·410	2·297
8	8·37	49·26	·05	37·49	48·560	2·302
10	324·47	350·10	·04	37·39	48·711	2·308
12	280·55	290·92	·03	37·32	48·863	2·313
14	236·64	231·75	·02	37·25	49·014	2·318
16	192·72	172·57	·02	37·19	49·165	2·324
18	148·80	113·39	+0·01	37·14	49·316	2·329
20	104·88	54·20	·00	37·11	49·467	2·334
22	60·95	355·02	·00	37·08	49·617	2·340
24	17·02	295·83	·00	37·06	49·769	2·345
26	333·08	236·63	·00	37·06	49·920	2·350
28	289·14	177·43	·00	37·06	50·071	2·356
30	245·18	118·21	·00	37·08	50·222	2·361
Apr. 1	201·23	58·99	·00	37·10	50·373	−2·366
3	157·26	359·77	−0·01	37·13	50·524	2·371
5	113·28	300·53	·02	37·18	50·675	2·376
7	69·30	241·29	·03	37·23	50·826	2·381
9	25·30	182·03	·04	37·30	50·977	2·386
11	341·29	122·76	·05	37·37	51·128	2·391
13	297·27	63·48	·06	37·46	51·279	2·396
15	253·24	4·19	·07	37·55	51·430	2·401
17	209·20	304·90	·09	37·64	51·581	2·406
19	165·14	245·57	·10	37·76	51·731	2·411
21	121·07	186·24	·12	37·88	51·882	2·416
23	76·99	126·90	·13	38·01	52·033	2·421
25	32·89	67·55	·15	38·14	52·184	2·426
27	348·78	8·17	·17	38·29	52·336	2·431
29	304·65	308·79	·18	38·44	52·487	2·436
May 1	260·51	249·39	−0·20	38·60	52·638	−2·440
3	216·35	189·97	·22	38·77	52·788	2·445
5	172·18	130·54	·24	38·95	52·939	2·450
7	127·99	71·09	·26	39·13	53·090	2·455
9	83·79	11·63	−0·28	39·32	53·241	−2·460

Greenwich Noon.	P	L−O	B	Apparent Diameter. Equat. 2a.	Defect.	Polar 2b.	d	w	B′
1898.	°	°	°	″	″	″	°	°	°
May 11	25·418	45·231	−2·390	42·15	0·21	39·52	8·16	89·36	−2·55
13	25·420	45·141	2·379	41·94	·22	39·31	8·40	89·27	2·54
15	25·422	45·063	2·368	41·73	·23	39·11	8·63	89·18	2·53
17	25·424	44·996	2·358	41·51	·25	38·90	8·85	89·09	2·52
19	25·425	44·942	2·348	41·28	·26	38·70	9·05	89·01	2·51
21	25·426	44·898	2·339	41·06	·27	38·49	9·25	88·94	2·50
23	25·426	44·867	2·330	40·83	·28	38·27	9·43	88·88	2·49
25	25·427	44·849	2·321	40·60	·29	38·06	9·60	88·81	2·48
27	25·427	44·842	2·312	40·36	·29	37·83	9·76	88·74	2·47
29	25·426	44·848	2·304	40·13	·30	37·62	9·90	88·67	2·46
31	25·426	44·866	2·296	39·90	·30	37·40	10·04	88·60	2·45
June 2	25·425	44·897	−2·289	39·67	0·31	37·19	10·16	88·54	−2·44
4	25·424	44·939	2·282	39·44	·31	36·96	10·26	88·48	2·43
6	25·423	44·993	2·276	39·21	·32	36·75	10·36	88·42	2·43
8	25·421	45·058	2·270	38·97	·32	36·54	10·45	88·37	2·42
10	25·419	45·135	2·264	38·75	·33	36·32	10·52	88·32	2·41
12	25·417	45·223	2·259	38·52	·33	36·11	10·59	88·28	2·41
14	25·414	45·322	2·254	38·29	·33	35·89	10·64	88·23	2·40
16	25·411	45·433	2·250	38·07	·33	35·69	10·68	88·19	2·40
18	25·408	45·554	2·246	37·84	·33	35·47	10·71	88·14	2·40
20	25·405	45·686	2·242	37·62	·33	35·26	10·73	88·09	2·39
22	25·401	45·829	2·239	37·40	·33	35·06	10·73	88·04	2·39
24	25·397	45·983	2·236	37·19	·32	34·85	10·73	88·00	2·39
26	25·392	46·147	2·234	36·97	·32	34·65	10·72	87·96	2·38
28	25·387	46·321	2·233	36·76	·32	34·45	10·69	87·92	2·38
30	25·381	46·504	2·232	36·55	·32	34·26	10·66	87·88	2·38
July 2	25·374	46·698	−2·231	36·35	0·31	34·07	10·62	87·85	−2·38
4	25·367	46·901	2·230	36·15	·31	33·88	10·57	87·81	2·38
6	25·359	47·113	2·229	35·95	·30	33·70	10·50	87·78	2·38
8	25·350	47·335	2·230	35·75	·30	33·51	10·43	87·74	2·38
10	25·341	47·565	2·231	35·56	·29	33·33	10·36	87·71	2·38
12	25·332	47·803	2·232	35·38	·28	33·16	10·27	87·67	2·38
14	25·322	48·050	2·233	35·19	·28	32·98	10·17	87·64	2·38
16	25·311	48·306	2·235	35·01	·27	32·82	10·07	87·60	2·38
18	25·299	48·569	2·237	34·83	·26	32·65	9·95	87·56	2·39
20	25·286	48·840	2·240	34·65	·25	32·49	9·83	87·52	2·39
22	25·273	49·119	2·243	34·49	·25	32·33	9·71	87·48	2·39
24	25·259	49·406	−2·246	34·33	0·24	32·18	9·57	87·44	−2·40

Greenwich Noon.	Longitude of ♃'s Central Meridian. 877°·90 I.	870°·27 II.	Corr. for Phase.	Light-time.	A−O	B
1898.	°	°	°	m	°	°
May 11	39·58	312·16	− 0·30	39·51	53·392	−2·465
13	355·34	252·66	·32	39·72	53·543	2·470
15	311·10	193·16	·33	39·92	53·694	2·474
17	266·84	133·64	·35	40·13	53·843	2·479
19	222·56	74·11	·36	40·34	53·995	2·484
21	178·27	14·55	·37	40·57	54·146	2·489
23	133·96	314·99	·38	40·79	54·297	2·493
25	89·63	255·40	·40	41·03	54·448	2·498
27	45·30	195·81	·41	41·26	54·599	2·503
29	0·94	136·19	·42	41·51	54·751	2·507
31	316·58	76·58	·44	41·74	54·902	2·512
June 2	272·20	16·93	−0·45	41·99	55·053	−2·516
4	227·81	317·28	·46	42·24	55·203	2·521
6	183·41	257·62	·47	42·48	55·354	2·525
8	138·98	197·94	·48	42·74	55·505	2·530
10	94·55	138·25	·48	42·99	55·656	2·534
12	50·11	78·55	·49	43·24	55·807	2·539
14	5·66	18·84	·49	43·50	55·958	2·543
16	321·19	319·12	·50	43·75	56·109	2·548
18	276·71	259·37	·50	44·02	56·260	2·553
20	232·22	199·62	·50	44·28	56·411	2·557
22	187·71	139·86	·50	44·54	56·562	2·562
24	143·21	80·10	·50	44·79	56·712	2·566
26	98·68	20·32	·50	45·05	56·863	2·571
28	54·15	320·52	·50	45·31	57·014	2·575
30	9·61	260·72	·50	45·57	57·165	2·580
July 2	325·06	200·92	−0·49	45·82	57·316	−2·584
4	280·50	141·10	·49	46·08	57·467	2·588
6	235·94	81·28	·48	46·33	57·618	2·592
8	191·36	21·44	·48	46·59	57·769	2·597
10	146·78	321·59	·47	46·84	57·920	2·601
12	102·18	261·75	·46	47·09	58·071	2·605
14	57·59	201·89	·45	47·34	58·222	2·610
16	12·99	142·03	·44	47·57	58·372	2·614
18	328·37	82·16	·43	47·82	58·523	2·618
20	283·76	22·28	·42	48·06	58·674	2·623
22	239·13	322·40	·41	48·30	58·825	2·627
24	194·50	262·51	−0·40	48·53	58·977	−2·631

LEEDS PHILOSOPHICAL AND LITERARY SOCIETY.

Greenwich Noon.	P	L−O	B	Apparent Diameter. Equat. 2a.	Defect.	Polar 2b.	d	w	B′
1898.	°	°	°	″	″	″	°	°	°
July 26	25·243	49·700	−2·250	34·17	0·23	32·03	9·43	87·41	−2·40
28	25·226	50·001	2·254	34·01	·22	31·88	9·28	87·37	2·40
30	25·208	50·308	2·258	33·85	·21	31·74	9·12	87·32	2·41
Aug. 1	25·189	50 624	−2·263	33·71	0·20	31·59	8·96	87·27	−2·41
3	25·169	50·944	2·268	33·56	·19	31·46	8·79	87·22	2·42
5	25·149	51·271	2·273	33·42	·18	31·32	8·61	87·17	2·42
7	25·127	51·604	2·278	33·28	·18	31·20	8·43	87·13	2·43
9	25·104	51·943	2·284	33·15	·17	31·08	8·24	87·08	2·44
11	25·079	52·287	2·290	33·02	·16	30·95	8·05	87·03	2·44
13	25·053	52·636	2·297	32·90	·16	30·83	7·85	86·99	2·45
15	25·026	52·992	2·304	32·77	·15	30·72	7·65	86·94	2·46
17	24·997	53·353	−2·312	32·66	0·14	30·61	7·44	86·89	−2·47

Greenwich Noon.	Longitude of ♃'s Central Meridian. 877°·90 I.	870° 27 II.	Corr. for Phase.	Light-time	A−O	B
1898.	°	°	°	m	°	°
July 26	149·88	202·63	−0·38	48·75	59·128	−2·635
28	105·24	142·73	·37	48·98	59·279	2·639
30	60·59	82·83	·36	49·20	59·430	2·644
Aug. 1	15·94	22·92	−0·35	49·42	59·581	−2·648
3	331·29	323·00	·34	49·64	59·731	2·652
5	286·64	263·10	·33	49·84	59·882	2·656
7	241·98	203·18	·31	50·05	60·033	2·660
9	197·32	143·26	·30	50·24	60·184	2·664
11	152·65	83·33	·28	50·45	60·335	2·668
13	107·99	23·41	·27	50·64	60·486	2·672
15	63·31	323·48	·26	50·83	60·637	2·676
17	18·65	263·55	−0·24	51·00	60·788	−2·680

The times of passage of the zero meridian of either system across the centre of the illuminated disc may be found by the method given on p. 31.

7 *Vanbrugh Park Road, Blackheath, S.E.:*
1898 *January* 19.